TRANSPARENT PACKING MODELS OF LAYER-LATTICE SILICATES BASED ON THE OBSERVED STRUCTURE OF MUSCOVITE

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ABSTRACT

A simple jig is described for the construction of a model of the muscovite structure in which the distorted hexagonal, i.e., ditrigonal, arrangement of the basal oxygens of the tetrahedra is accurately represented. The model is of the packing kind as opposed to the ball-and-spoke kind and demonstrates the advantages of this type of model, which would be more generally used if transparent plastic balls were available commercially.

INTRODUCTION

Whilst the majority of atomic structure models used both for teaching and research purposes are of the ball-and-spoke kind, packing models may be far more realistic for teaching and may assist considerably in research. This has been emphasised previously by Hatch, Comeforo and Pace (1952), who also described techniques for making models of hollow, transparent, tinted plastic balls, and pointed out the several notable advantages of such models.

Previous models of the ideal mica structure (Jackson and West, 1930) have necessitated the use of enlarged octahedral ions (in order to make this layer close-packed whilst allowing the surface oxygens of the tetrahedral layer to remain in a hexagonal network) together with enlarged potassium ions to produce the deduced separation between layers.

A detailed determination of the structure of muscovite (Radoslovich, 1960) shows that (a) the octahedral anions are not in contact with each other, (b) the layer surfaces are not hexagonal but ditrigonal due to rotation of the tetrahedra, and (c) the holes so produced are smaller than the diameter of the potassium ion. Other micas are probably similar in some of these respects (Radoslovich, 1961).

JIG FOR CONSTRUCTING MUSCOVITE MODEL

A simple jig allows the rapid construction of a muscovite model having such features. Suppose the scale is $\frac{1}{8}$ in. = 1Å, the oxygen
diameter being 2.6 Å. For $b_{obs}=9.0$ Å and $b_{tetr.}=9.3$ Å the tetrahedral rotation, $\alpha=13\frac{1}{8}^\circ$ (Radoslovich, 1961). In the ideal structure the silicon ions are on a hexagonal grid of side $2.6 \times \frac{2}{\sqrt{3}}$ Å, which becomes in the ditrigonal model $\frac{2.6 \times 9.0 \times 2}{9.3 \times \sqrt{3}} = 1.45$ in.

The jig consists of a piece of wood with paper attached inscribed with a hexagonal grid, sides 1.45 in. The tetrahedral cations will lie vertically above the centres of some of these hexagons; and where this is so a nail ($N$, Fig. 1) with a $\frac{3}{8}$ in. diameter head is partly driven in. The height of the nail is adjusted until a tetrahedron constructed of oxygen balls will just sit on its base ($X, Y, Z$, Fig. 1) over the nail, without wobbling or movement other than rotation. The twist of $13\frac{1}{8}^\circ$ is set out with a protractor at a number of these nail points, and thin brads ($B$, Fig. 1) are fixed so that when a tetrahedral group is placed over the nail the brad lies between two oxygens, $Y$ and $Z$, to give the group its twist. In fact three brads will fix one ditrigonal ring (Fig. 1), and all other tetrahedra will, with careful construction, adjust themselves to make the whole model ditrigonal.

![Diagram of jig for constructing muscovite model.](image)
The hydroxyls (U, Fig. 1) are situated above the centres of the ditrigonal holes, but not touching X, Y, and Z, so that they must be supported by being glued to the octahedral cations only, which are in turn glued to the apical oxygens, V, W, etc. Thin nails are therefore fixed at the centres of the ditrigons, and covered with lumps of plasticine, on to which the hydroxyls are pressed until they are level with V and W. The octahedral cations may now be inserted and glued, after which the whole layer may be lifted free of the jig. A second tetrahedral layer is then constructed on the same jig.

At this point one must decide how the model is to be dissected, if at all. Our model can be split at the octahedral layer because the hydroxyls for the top tetrahedral layer have been glued on the top of the previously constructed layer; thus, they are correctly attached to the octahedral cations. The second tetrahedral layer fits this layer readily because of the gaps between neighbouring octahedral anions. The model is completed by glueing (or loosely positioning) tinted spheres for the potassiums (Fig. 2).

This model and jig may be used for other structures quite readily. Thus, for kaolinite loose hydroxyls can be added to the layer constructed first and for chlorite the inter-layer potassium ions are omitted and replaced by a brucite layer (Fig. 3). In constructing the brucite layer the second tetrahedral layer should begin using oxygen

Fig. 2—Edge view of muscovite model.
triads only; when this triad sheet has been glued it forms a jig on which to place hydroxyls for the construction of brucite, on the same scale as muscovite. Other micas, such as trioctahedral micas, can obviously be formed using extra cations, and micas with different twists can be made by changing $a$ in the above.

**DISCUSSION**

These models effectively illustrate several features of the mica structures. (a) The rotations in the tetrahedral layer force the interlayer potassium out of the surface (Fig. 2) sufficiently to keep successive muscovite layers clearly separated (Radoslovich, 1960).

![Fig. 3—Edge view of chlorite model.](image)

(b) Larger octahedral cations will increase the space between the anions, thereby expanding this layer and untwisting the tetrahedral layers (Radoslovich, 1961). (c) The ditrigonal symmetry of the surface networks is obvious (Figs. 1 and 4) and this can be related to mica polymorphism (Radoslovich, 1959) by superimposing layers across the interlayer region. These figures should be compared with those of Hatch, Comeforo and Pace (1952).

**NEED FOR A SOURCE OF SPHERES**

The construction of silicate models would be much easier if hollow spheres (or hemispheres) of diameter 1.3 in., as described above, were available commercially. The present model requires 300-400
oxygen balls which also serve (when tinted) as hydroxyls, fluorines, potassiuoms or bariums; with the scale adjusted they would represent sulphurs in sulphide models. Making these balls takes the major part of the construction time; the smaller opaque balls present little difficulty. It is therefore suggested, in support of the plea by Hatch, Comeforo and Pace (1952), that, if the demand were sufficient,*

*It might be possible to assess demand and organize production through one of the professional societies; meantime, the authors would be glad to hear from others interested.